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THE USE OF CHEMICALS AS HERBICIDES

AGRICULTURAL CHEMICALS TECHNOLOGY
No. 6

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

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This publication is a portion of the course material written in Agricultural Chemicals Technology. To be understood fully, the complete set of materials should be considered in context. It is recommended that the following order be observed for a logical teaching sequence:

#1 - The Use of Chemicals as Fertilizers

#2 - The Use of Chemicals as Insecticides - Plants

#3 - The Use of Chemicals as Soil Additives

#4 - The Use of Chemicals as Fungicides, Bactericides and Nematocides

#5 - The Use of Chemicals to Control Field Rodents and Other Predators

#6 - The Use of Chemicals as Herbicides

#7 - The Use of Chemicals in the Field of Farm Animal Health (Nutrition, Entomology, Pathology)

#8 - The Use of Chemicals as Plant Regulators

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THE USE OF CHEMICALS AS HERBICIDES

Major Teaching Objective

To develop personal qualities and effective abilities needed for entry and advancement by technicians in occupations which pertain to chemical weed control.

Secondary Objectives

1. To develop an interest in and an appreciation of the part which chemicals have in controlling weeds.

2. To gain an understanding of the principles of plant growth, soil science, and chemistry as they relate to the use of herbicides.

3. To gain knowledge and skills essential to the qualification of technicians for work in the area of chemical weed control.

Suggested Time Allotment

At school		
Class instruction	24 hours	
Laboratory experience	36 hours	
Total at school		60 hours
Occupational experience		60 hours
Total for the Course		120 hours

Suggestions for Introducing the Course

The following suggestions may be helpful in arousing a high level of interest in students at the beginning of this unit:

1. Demonstrate for the students, using flats or plots of plants especially grown for this purpose, the effects of using herbicides. Show the selectivity of some chemicals, the

speed with which some chemicals act, and the persistence some chemicals have in preventing weed germination and growth. Be sure in each case to use a control (no treatment) for contrast.

2. With information obtained from workers in industry, business, public service, and education develop a list of the skills, abilities, and understandings which agricultural chemical technicians need for employment in the herbicide industry. The list will probably include entries for each of the following sub-headings:

   a. Man's use of chemicals to attempt to control weeds

   b. Federal, state, and local laws, regulations, and controls which pertain to the sale and use of herbicides

   c. The recognition and identification of weeds which are commonly encountered

   d. Various chemical resources which are available for use to control weeds

   e. The principles of plant growth, soil science, and chemistry which are related to the use of chemicals to control weeds

   f. Skills, abilities, and understandings needed to plan a weed control program

   g. Important terms, nomenclatures, definitions, tables, charts, and guides common to the field and important computations, calculations, conversions, and measurements performed

   h. The handling and applying of herbicides in the proper manner, using approved methods and equipment

3. Develop a list of factors, with the help of the students, which tend to complicate the task of controlling weeds by the use of chemicals. Included might be such items as:

   a. Dissemination of plants

   b. Plant physiology

   c. Existing soil and water relationships

   d. Growth habits; i.e., depth roots penetrate the soil

e. Formulations of chemicals

f. Application equipment

4. Review the history of:

a. The weed control program of one of the progressive farmers in the area

b. The use of herbicides in the local and regional areas

Competencies to be Developed

I. To develop an interest in and an appreciation and understanding of man's use of chemicals to attempt to prevent, control, or eradicate weeds.

Teacher Preparation

Subject Matter Content

Review relevant aspects of plant nutrition, plant psysiology, soil science, and chemistry as they are related to the use of herbicides. Examine what man attempts to do with herbicides, what the herbicide industry is like, and some of the problems encountered in an attempt to prevent, control, or eradicate weeds chemically.

1. Review (material previously covered in other courses)

   a. Plant nutrition and physiology

      1) The life processes of plants are many and varied; they are complex and delicately balanced. Disturb one, even slightly, and a chain of events may be set off that will cause major changes in the plant's metabolism.

   b. Soil Science

      1) Many factors influence the effectiveness of an herbicide Herbicides applied to the soil are directly affected by soil characteristics. Herbicides applied directly to the foliage of plants are affected less by soil differences.

         The numerous soil factors, the many different kinds of herbicides and the large number of plant species and climatic variations make the study of herbicides in soils very complex and diverse. There are at least 10 different soil variables of major importance: texture, moisture, temperature, organic matter, microorganisms, mineral constituents, colloidal properties, aeriations, structure of top and subsoils and pH (soil reaction).

   c. Chemistry

      1) Herbicide selectivity refers to the characteristic of a chemical that makes it more toxic to one plant than to another. When such an herbicide is applied to a mixture of plants, some may be killed and others may be affected only slightly or not at all.

         Selectivity is based upon many factors. The most important factors are:

         a) Morphological or Structural Differences which

            --permit selective application of herbicides

-- permit protection of the plant meristematic regions from herbicidal injury

-- involve plant surface differences or orientation of plant parts which may affect spray retention and herbicide absorption

b) Absorption. Some plant surfaces absorb the herbicide quickly. Other plant surfaces absorb the chemical slowly, if at all. The chemical nature of the herbicide is also involved. Therefore, differential absorption or selective absorption may account for differences in plant responses.

c) Translocation Differences. Translocation of herbicides is a major problem in the control of weeds with below-ground reproductive organs. Translocation of herbicides within the plant involves

-- translocation through the phloem

-- translocation in the xylem

-- intercellular translocation

d) Physiological Differences. The physiological differences in plants which account for selective herbicidal toxicity is only partially understood. Differences in enzyme systems, response to pH changes, cell metabolism, cell permeability, variations in chemical constituents, and polarity may be involved. A change in one or more of these may result in either blocking or stimulating certain biochemical processes. The entire metabolic process may be thrown out of balance. Often it is difficult to separate the primary effects of an herbicide from secondary effects.

2) Types of Toxicity. Two types of toxicity to plant tissue, acute and chronic, have been noted. The word acute is used here to mean "intense" or "penetrating;" thus, acute herbicidal toxicity is an intense, rapid killing of the plant. Sometimes, though, the plant may survive if it is not immediately killed; it suffers only a temporary setback. Contact herbicides usually produce acute toxicity. The word chronic as used here means "of long duration" or "continuing for a long time." Therefore, chronic herbicidal toxicity is slow-acting. Under some conditions the plant may show little visible effect for a week or longer. It may die 3 to 10 weeks after treatment. Growth regulators usually produce chronic toxicity.

3) Concentrations. Concentration may determine whether the herbicide inhibits or stimulates the plants. The concentration of the herbicide at a vital location in the plant at any one given time may determine the herbicide effectiveness.

4) Carriers. In many sprays the bulk of the volume is made up of a carrier or diluent. This extends the active ingredients so they may cover the plant surfaces evenly. Water is the most common carrier, and it lends driving force to the spray solution because of its high density and surface tension. Oil is a better carrier than water because it has a low surface tension and high wetting ability. Oil may be used where creeping of the spray solution into the crowns of grasses and rosettes of weeds is required.

2. The problem - The Need for Weed Control

a. Man's need to control weeds

1) Weeds are important to almost everyone. Weed control is one of the most expensive steps in crop production. Weeds may poison or seriously slow down weight gains of livestock. They may cause allergies such as hay fever and poison ivy. They infest home lawns and gardens. Weeds create problems in recreation areas such as golf courses, parks, and fishing and boating areas. They are troublesome along highways, railroads, industrial areas, and irrigation and drainage systems.

Weeds are costly. They take water, fertilizer, and light from the crop plants. They often reduce yield and quality of crop and livestock products. They increase labor and equipment costs, harbor insect and disease organisms, and reduce land values. The cost of weeds to the American farmer is estimated at $5,000,000,000 annually. In certain crops the losses due to weeds can exceed $100 per acre. In many crops these losses can mean the difference between success and failure to the grower.

3. Solution to the problem

a. Losses can be reduced by three principal means - weed prevention, eradication, and control.

1) Weed prevention means primarily good farm sanitation. You start with weed-free fields, and prevent weeds from being introduced and from spreading. Preventive methods include the use of clean seed, cleaning contaminated equipment, keeping fence row and ditch bank weeds from seeding and spreading, and spot-treating small weed infestations within the field.

2) Weed eradication completely destroys or removes all weed plants including regenerative plant parts. Eradication is sometimes justifiable, as in the case of small new infestations of particularly troublesome weeds, even at relatively high costs per unit area or loss of selectivity.

3) Weed control is in most instances the most reasonable approach. Many weeds are so widespread that eradication, though desirable, becomes economically impractical. But weed infestations can be reduced to a level that will enable a crop to be produced profitably in spite of the weeds.

4. Weed control methods

a. Mechanical control includes cultivation, mowing, disking, hoeing, and many other cultural practices.

b. Cropping methods take advantage of crop rotations to obtain changes in the environment which will keep weeds down. Often the new crop successfully competes with the weeds from the previous crop. A good rotation for weed control usually includes strong competitive crops grown in each part of the rotation plus both summer row crops and winter or early spring grain crops.

c. Biological control methods use living organisms to control weeds. Insects or disease organisms are the usual tools used. However, parasitic plants, selective grazing by livestock, geese, and rodents are also important.

d. Fire is effective in removing weeds from ditch banks, roadsides, and other waste places. Special burners for flaming small annual weeds have been successful in crops such as cotton, corn, and sorghum.

e. Chemical weed control offers the greatest potential. It is not new but has developed rapidly and extensively in the past several years. Three types of herbicides classified according to their effects on plants are shown below.

5. The use of chemicals to control weeds

a. Kinds of chemicals available for weed control

1) Contact herbicides kill plant parts covered by the chemical. The chemical must be directly toxic to living cells. Generally the effects are acute and the plant dies quickly or soon after treatment. Adequate distribution of the herbicide over the foliage is essential. Contact herbicides may be selective or non-selective.

2) Growth regulators are also called growth modifiers, growth substances, translocated herbicides, and systemic herbicides. These herbicides are absorbed by either the roots or above-ground parts and move through the plant system. The plant's growth and metabolic processes are upset by the chemical. They have a chronic effect. Growth regulators are usually effective on certain plants but not on others, making possible selectivity in plant kill.

3) Soil sterilants are any chemicals which prevent the growth of green plants when present in the soil. These treatments are usually applied to the surface of the soil but may also be incorporated into the soil by cultivation, or injected below the soil. If the chemical sterilizes the soil for less than 48 hours, it is said to have no residual toxicity. If the soil is sterile for 4 months or less it is considered a temporary soil sterilant; from 4 months to 2 years as a semi-permanent sterilant; and for more than 2 years as a permanent soil sterilant.

b. Examples of well-known weed control programs

1) Cite programs of the local area

2) Other (Klamath weed, etc.)

c. Major determinations required in a weed control program

1) Kind of chemical to use

2) Time

3) Placement

4) Amounts

5) Methods of application

6) Costs

7) Dangers, hazards

d. What results can be expected from the use of herbicides

1) Cite local examples

e. The importance of using herbicides

1) Economic

Herbicides were used to control weeds on more than 70 million acres of agricultural land in

1962 at a cost of more than $272 million as compared to approximately 53 million acres and $128 million in 1959. These data do not include the use of herbicides on industrial areas and other type of agricultural land.

Shaw, W. C. - Weed Science

f. Problems of using herbicides

1) Safety factors for humans, livestock, and wildlife

2) Contamination of other crops by drift of herbicide

3) Dosage and calibration

4) Cleanliness of equipment

5) Proper equipment

6) Mixing of herbicides with other chemicals

7) Residues on soil and crops

6. The Herbicide Industry

a. History and development

1) Review which may be helpful is Crafts and Robbins, 1962, Weed Control, 3rd Edition, McGraw-Hill, Chapter 9, pp. 173-177.

b. Present status and situation

1) Dynamic and expanding (discuss)

c. Recent changes and future trends

1) Emphasis on research (basic and applied)

2) Increased utilization and development of selective herbicides

3) Emphasis on regulatory needs and laws

4) Emphasis on education

5) Emphasis on use of surfactant, co-solvent, other adjuvants and mixtures of herbicides

Suggested Teaching-Learning Activities

1. Have the students bring in labels or small sized used containers of herbicides. As a class project, summarize information available from these items -brand names, major procedures, trade names, active ingredient, and instructions for use.

2. Select a representative number of farms in the area and with the cooperation of the grower:

   a. Determine the weed control program practiced.

   b. Ascertain the amounts and kinds of herbicides used.

   c. Attempt to compute the approximate value which occurred as a result of having used (1) a total weed control program and (2) herbicides.

   d. Determine what problems were encountered in the conduct of these various weed control programs.

3. Demonstrate the toxicity, lethal effects, and residues of one of the well-known herbicides.

4. Establish a small, mixed weed, demonstration plot which can be used to demonstrate the effectiveness of different types of herbicides.

5. Talk by county agriculture commissioner or farm advisor on herbicide utilization in local area.

Suggested Instructional Materials and References

Klingman, Glen C., Weed Control: As a Science, John Wiley & Sons, Inc., 1961.

Crafts, Alden S. and Robbins, Wilfred W., Weed Control, 3rd Edition, McGraw-Hill Book Company, Inc., New York, 1962.

The British Weed Control Council, Weed Control Handbook, 3rd Edition, Blackwell Scientific Publications, Oxford, 1963.

State Extension and Experiment Station Publications.

II. To develop the ability to use important terms, nomenclature, definitions, tables, charts, and guides which are used in the field and also to develop the ability to perform important computations, conversions, calculations, and measurements which are commonly performed by technical workers in the field of weed control.

Teacher Preparation

Subject Matter Content

Note: This unit is presented here at an early point in the study guide in order that the instructor may review it and make plans to make use of the data and information provided for herein throughout the remainder of the course. It is not intended that the unit will be taught as a separate competency, as are the other six major units of the course, but that the material provided for here will be integrated as appropriate throughout the rest of the study. The purpose of this section then is to provide for the pulling together in one place a core of information appropriate to the course.

It will be necessary for the instructor to gather information and materials from various courses including the ones recommended in this unit.

Guidelines in the form of an outline for use in summarizing data gathered pertinent to this section are presented.

Data presented in this section of the study guide for the course "the Use of Chemicals as Insecticides" may be useful.

SECTION ONE - General Information

THE STUDENT WILL NEED TO BE ABLE TO:

1. Make use of words, terms, and phrases appropriate to the subject matter of the course. A Glossary of Terms will facilitate this usage.

2. Perform measurements, conversions, computations, and calculations commonly done by technical workers in the field. Tables containing units of measurement and tables of equivalents of units will be useful.

   a. Tables of measurement

      -- Linear measure - length

-- Square measure - area

-- Cubic measure - volume

-- Liquid measure - capacity

-- Dry measure - capacity

-- Weight measure

-- Temperature measure

-- Time measure

-- Other

b. Tables of convenient equivalents

-- Equivalent volumes - liquid measure

-- Equivalent volumes - dry measure

-- Equivalent weight/volume - liquid

-- Equivalent weight/volume - dry

-- Equivalent lengths

-- Equivalent areas

-- Equivalent weights

-- Equivalent temperatures

-- Equivalent other

SECTION TWO - Information Regarding Agricultural Chemicals

THE STUDENT WILL NEED TO MAKE USE OF:

1. A table which lists the common name, active ingredient, and trade name(s) of chemicals studied in the course.

   Example: TCA Trichloroacetic acid Sodium TCA, Na TCA

2. An alphabetical listing of chemicals commonly used in the field. Information such as the trade name, name of major producer, composition, formulation, and recommended use.

Example: Simazine (Geigy)

2-chloro-4,6-bis(ethylamino)-S-triazine,
80% active ingredient - wettable powder;
4% active ingredient - granule - herbicide
for use as registered.

3. A listing of chemical materials according to the general use.

Example: <u>Pre-emergence herbicides</u>

-- PCP

-- NPA

-- DNBP

<u>Post-emergence herbicides</u>

-- Diuron

-- MCPA

-- 2,4-D

4. Compatibility charts and tables

a. Phytotoxicity (with plants)

b. Chemicals (with other chemical)

c. Physical (with other chemical)

5. Toxicity tables providing LD and LC values (both oral and dermal, acute and chronic) of chemicals studied in the course.

6. Tolerance limitations imposed by F.D.A. upon residues applicable to the subject matter of the course (i.e., herbicides, insecticides, fungicides, etc.)

<u>What is one part per million</u>?

Most lay people have no conception of what constitutes one part per million residue on crops. The following examples may help you make this interpretation for them:

1. One inch is one part per million in 16 miles.
2. A postage stamp is one part per million of the weight of a person.
3. A one gram needle in a one ton hay stack is 1 ppm.
4. One part per million is one minute in two years.
5. Lay your hand on the ground and it covers 5 ppm of an acre.

6. If one pound of a chemical lands on an acre of alfalfa the hay has 500 ppm. One ounce of a chemical would impart 31 ppm.
7. A teaspoon of material on an acre of alfalfa would impart 5 ppm.
8. One teaspoon of DDT drifting onto 5 acres of alfalfa puts 1 ppm in the hay, and the Federal Law says that the hay must contain none.

(Source--Western Crops and Farm Management)

SECTION THREE - Preparation of Chemicals for Use

THE STUDENT WILL NEED TO BE ABLE TO:

1. Determine whether or not materials prepared and commercially packaged can be applied directly from the container.

2. Determine the total amount(s) of active ingredient(s) contained in a chemical mixture. Mixtures may vary according to weight, volume, concentration, and formulation.

3. Make a determination of the amounts, by weight or by volume, of chemical materials of various levels of concentration to use in order to prepare a given quantity of mixture that will meet recommended or specified dosage or concentration levels. (Weights or volumes of solid or liquid chemicals required to prepare a given quantity of material of different dilutions.)

4. Interpret tables and recommendations for "concentrate" spraying.

SECTION FOUR - Preparation Necessary in Order to Secure Specified or Recommended Application Rates

THE STUDENT WILL NEED TO BE ABLE TO:

1. Compute the area of various plots of land. These plots will vary in size, shape, topography, and planting.

   a. Determine acreage of row planting which vary according to spacing.

   b. Determine total acreage of plots.

2. Determine the speed of a vehicle traveling on the land. (In miles per hour and feet per minute.)

3. Three variables affect the application rate of agricultural chemicals secured in the field - the speed of travel, the

effective width of the device applying the chemical, and the total material delivered per unit of time. If two of these variables are known, calculate the other in order to secure a specific application rate.

a. Calibrate sprayers, dusters or metering devices to secure specific delivery rates.

b. Compute the length of boom, number of outlets, or width of opening to secure specific widths.

c. Calibrate ground speed to secure specific rate of forward travel.

4. Use tables of "Rate of Equivalents"

   Example: 1 ounce per square foot = 2722.5 pounds per acre

5. Calculate the quantity of spray per length of row (on various spacings) which will be equivalent to a specific application per acre.

6. Determine the gallons per acre required to spray orchards of different planting distances.

7. Consider the effect of particle size on drift and deposit. (Prepare spray drift and deposit table.)

SECTION FIVE - Information Relative to Diagnosis and Prescription

THE STUDENT WILL NEED TO MAKE USE OF :

1. Tables, charts, and guides which summarize situations encountered in agricultural production in which the use of chemicals is appropriate. Materials to use and methods of application are suggested.

   Examples of form used:

Plant or Soil	Pest, Disease or Condition	Causative Agent or Factor	When to Treat	What Material to Use
Alfalfa	Weeds	Spotted Alfalfa Aphid	At time of planting	Diuron

Active Ingredient Per Acre	Formulation	Amount Concentration Req'd Per Acre	Method of Application	Remarks
1/2-100 lbs. in 25-40 gallons of water. (The higher amounts are used as soil sterilant.)	25% Granules		Use only where alfalfa becomes dormant; for the control of seedling winter annual weeds.	Treat only established stands of one year or more.

2. Graphs, charts, tables, and other illustrative materials available and supportive of the unit under consideration.

   Examples:

   a. Graphical relationships

      -- time versus residue levels

      -- rates of application versus levels of effectiveness

      -- levels of concentration versus levels of effectiveness

      -- stage of development or growth versus effectiveness of chemical control, etc.

SECTION SIX - Sources of Information

1. Table 1, p. 41, Plant Regulators in Agriculture, Tukey (Common abbreviations of regulators and herbicides).

2. Table 1, pp. 89-192 - Same source as above. (Reactions of some weeds to 2,4-D.)

3. Pre-Harvest Use of 2,4-D on Citrus, Circular 528, California Experiment Station, Davis, California, 1964.

4. Weed Control as a Science - Klingman

   a. A comprehensive table of scientific names, common names, length of life, and susceptibility to 2,4-D; 2, 4, 5-T and Silvex.

   b. Chemical Terminology

   c. Conversion factors

   d. Nozzle capacities

   e. Spray patterns and pressure drops

   f. Tables of various mixtures

   g. Persistence of herbicides, p. 66

5. Principles of Selective Weed Control, Circular 505, California Agricultural Extension Service, Davis, California, 1961.

   a. Glossary of terms

   b. How to apply herbicides - calculations

6. 1965 Weed Control Recommendations, Leaflet 168, Revised California Agricultural Extension Service, Davis, California, 1965.

7. The Herbicide Encyclopedia, Frost, South Dakota State University, Extension Service, Brookings, South Dakota, 1965.

   a. Extensive listings of supplemental information

      -- Calibration of sprayers, tables of measurement and conversions, outline of herbicides, publications, surfactants, names (trade, brand, common) and herbicide use.

8. Agricultural Chemicals, W. T. Thompson, The Simmons Publishing Company, Davis, California, 1964.

   a. Entire publication contains information which would be useful in the preparation of various study guides and summarizations.

III. To learn to recognize and identify weeds which are commonly encountered; to understand the economic importance, life cycles, and detrimental effects of such weeds.

Teacher Preparation

Subject Matter Content

Note: Much of the subject matter of this unit has been considered in a previous course. The emphasis which should be placed in reviewing this unit is upon effective use of chemicals.

1. Identification of Weed Pests

   a. List the names of the weeds which pose the greatest threat to crop production in the local area.

      1) Obtain list from Crop Improvement Association, Seed Certification Agency, or State Agriculture Department.

   b. What types and extent of damage are likely from weeds?

      1) Crafts and Robbins, Weed Control, McGraw-Hill, 3rd Edition, Chapter 2, 1962.

   c. What problems are most likely to be encountered in establishing a weed control program ?

      1) Know your weed problem - individual characteristics.

         -- Growth habits

         -- Seed production

         -- Dissemination of seeds

         -- Germination of weed seeds

      2) Select the most appropriate method for its control.

         -- Chemical

         -- Tillage, cultivation, and mowing (cultural practice)

         -- Cropping

2. Weed Study

   a. Study in detail the weeds of the local area. Add to the following guide as appropriate.

1) Common name of weed

2) Important points of its life cycle to remember

3) Classification (annual, depth of rooting, broadleaf)

4) Type and extent of damage likely without control

Suggested Teaching-Learning Activities

1. Field trips to identify weeds in the field at different stages of growth.
2. Have weed plant mounts and seed samples for identification and study.
3. Use picture slides of weeds for teaching purposes.
4. Give training in the use of keys to identify weeds.

Suggested Instructional Materials and References

Experiment Station and Extension Publications

Muenscher, W. C., Weeds, New York, MacMillan Company, 1955.

Craft, A. S. and Robbins, W. W., Weed Control, McGraw-Hill Book Company, Inc., 1962.

IV. To become knowledgeable, at the technical level concerning various chemicals available for use as herbicides.

Teacher Preparation

Subject Matter Content

1. Introduction

   a. List the common forms of herbicides

      1) Granules

      2) Emulsifiable concentrates

      3) Oil solutions

      4) Aerosols

      5) Wettable powders

      6) Dusts

   b. What factors need to be considered when developing a chemical to be used as an herbicide?

      1) Analyze the potential market

      2) Synthesize 300 to 2,000 compounds

      3) Preliminary biological screening

      4) Select 10 to 50 promising compounds

      5) Synthesize 500 grams of each

      6) Perform secondary biological screening

      7) Determine acute toxicity to animals and humans

      8) Determine plant toxicity

      9) Make patent application

      10) Develop preliminary cost figures

      11) Select 1 to 6 compounds

      12) Synthesize 25 to 100 pounds of each

      13) Start field testing on plants

14) Conduct long-range testing of toxicity to animals, humans

15) Test effect on taste and quality of crops

16) Make samplings of residues left on plants

17) Register chemicals for experimental sales

18) Conduct studies on formulations

19) Start pilot plant construction

20) Study process and plant design

21) Do advanced field testing

22) Make analysis of residue left on plants

23) Conclude testing of toxicity to animals, humans

24) Petition FFDA for chemical residue tolerances

25) Petition registration of pesticide label with USDA

26) Build full-scale manufacturing facilities

27) Select packaging, labeling, and set prices

28) Produce sales literature and recommendations

29) Continue market studies and advertising

2. Chemicals Used as Herbicides

a. Classification of chemicals used as herbicides

1) Carboxylic-aromatic compounds

2) Aliphatic acids

3) Substituted phenols

4) Heterocyclic nitrogen derivatives

5) Aliphatic organic nitrogen derivatives

6) Metal-organic and inorganic salts

7) Other organic herbicides

The Herbicide Encyclopedia, So. Dak., p. 151.

b. Properties and characteristics of herbicides (learn for each herbicide studied)

1) Classification, common name, trade or brand name, scientific name

2) Chemistry - active ingredients, composition, physical makeup

3) Industrial preparation, manufacture or formulation

4) Phytotoxicity, effectiveness, acute oral toxicity, types

5) Analysis of mixtures

6) Compatibility with other chemicals

7) Carriers used, diluents, spreaders

8) Approximate price

9) Registered use

10) Recommended uses (general crops and soils, weeds)

-- Concentrations

-- Selectivity

-- Forms available

-- Water solubility

Agriculture Chemical Book II Herbicides
The Herbicide Encyclopedia, So. Dak.

3. Guide for the Study of Agricultural Chemicals

Note: The instructor will determine which chemicals are to be studied in depth. This selection of course depends upon the requirements of local areas and situations. Other items should be added to the guide as appropriate.

1) Chemical name (active ingredient)

2) Empirical formula

3) Chemical structure

4) Common name

5) Trade name(s) and major producer (s)

6) Melting point

7) Vapor pressure

8) Solubilities

9) Odor

10) Color

11) Density

12) Physical state (liquid, solid, gas)

13) Corrosive action

14) Flammability

15) Stability

16) Compatibility

17) Suitable diluents

18) Concentrations

19) Purities/grades

20) Mixtures available

21) Industrial preparation

22) Formulations for use/additives used

23) Analytical methods

24) Analysis of mixtures

25) Phytotoxicity

26) Toxicity (LD_{50}, LC, ppm oral, dermal, acute, chronic)

27) Special hazards

28) Residues likely, tolerance limitation

29) Synergists possible for use

30) Intended general use (insecticide, fertilizer, nematocides, etc.)

31) Intended specific use

32) Antidotes and first aid

33) Factors which limit the effectiveness of the chemical (such as temperature, sunlight, water, etc.)

Suggested Teaching-Learning Activities

1. Show films and visual aids.
2. Study chemical formulation.
3. Visit chemical formulation plant.
4. Make file cards with properties and characteristics of each herbicide.

Suggested Instructional Materials and References

The Herbicide Encyclopedia, Compiled by K. R. Frost, Jr., Extension Agronomist-Weeds, South Dakota, State University, Brookings, South Dakota, 1965.

Thompson, W. T., Agricultural Chemicals Book II - Herbicides, The Simmons Publishing Company, Davis, California, 1964.

Klingman, Glenn C., Weed Control: As a Science, New York, John Wiley & Sons, Inc., 1961.

V. To gain a knowledge and understanding of the principles and concepts underlying the use of chemicals to prevent, control, or eradicate weeds.

Teacher Preparation

Subject Matter Content

1. Principles Underlying Use of Herbicides
    a. The chemical action of herbicides
        1) Foliage treatment
            a) Contact
                -- Pre-planting (crop)
                -- Pre-emergence (crop)
                -- Post-emergence (crop)
            b) Translocated
        2) Soil treatment
            a) Contact (roots)
                -- Pre-planting
                -- Pre-emergence
                -- Post-emergence
            b) Translocated
            c) Soil sterilant
                -- No residual
                -- Temporary
                -- Semi-permanent
                -- Permanent
    b. The use of surfactants
        1) Basic concepts
            a) Surface relationships
                -- Liquid to liquid forms an emulsion

-- Solid to liquid forms a suspension

-- Solid to air forms a dust

-- Liquid to air forms a fog or mist

-- Surfactants modify the surface forces (interfaces) by orienting itself between the interfaces, providing a more intimate coupling.

b) Surface tension is defined as the tendency of the surface molecules of a liquid to be attracted toward the center of the liquid body.

2) Types of surfactants

a) Non-ionic - usually liquids not electrolytes, usually chemically inactive. Many emulsifying agents of this type.

b) Ionic - ionize in aqueous medium

-- Anionic - anion (-) part of molecule is predominant, i.e., wetting agents, detergents, and some emulsifiers.

-- Cationic - cation (+) part of molecule is predominant, i.e., invert soaps.

Note: Anionic agents will improve performance in cold water and work best in soft water. Non-ionic forms perform better in warm water and in hard water.

3) Surfactants classed according to use

a) Wetting agents

b) Emulsifiers

c) Detergents

d) Spreaders

e) Adhesive or sticking agents

f) Dispersing agent

4) Effect on plants

a) Favor uniform spreading or wetting of plant

b) Spray droplets tend to stick to the plant

c) Chemical spray brought into intimate contact with the plant

d) May solubilize non-polar plant substances

e) Detergents may affect proteins, i.e., precipitation, denaturization, and inactivation of enzymes, viruses, and toxins

c. Time to apply herbicides (in terms of the principle of optimum time)

1) Persistence in the soil

2) Cultivation of crops

3) Rotation of crops

a) Pre-emergence - time

b) Post-emergence

d. Amounts of herbicide to apply

1) Follow State Experiment Station recommendations

e. Placement of herbicides or area of application

1) Broadcast

2) Band

3) Directed sprays

4) Spot treatment

f. Method of application

1) Spraying

-- Knapsack sprayers

-- Small hand-propelled equipment

-- Tractor mounted on trailed machines

-- Airblast machines

-- Band sprayers

-- Aircraft sprayers

2) Dusting machines

3) Granular herbicide applicators

4) Fumigant injectors

5) Subsurface applicators

6) Soil incorporation

Suggested Teaching-Learning Activities

1. Visit to local agricultural chemical formulator and applicator.

2. Demonstrate incompatibilities of herbicides.

3. Prepare a number of different formulations of herbicides. Apply to various specimen and note results. Interpret action of the chemicals on the basis of principles studied in this unit.

4. Prepare a study guide as a class project of the characteristics and uses of various supplemental agents used in formulating herbicides.

Suggested Instructional Materials and References

Klingman, Glenn C., Weed Control: As a Science, John Wiley & Sons, Inc., 1961.

State Experiment Station and Extension Publications.

VI. To gain an understanding and knowledge needed to develop weed control programs in general and also to be able to control selected weeds.

Teacher Preparation

Subject Matter Content

1. Use of Herbicides in General

   a. There are more than 100 chemicals available for weed control. Some of these are for very specific purposes, others for general use. Some are obsolete, others are dangerous to use. In addition there are new materials not approved yet. Many of these chemicals, of course, accomplish the same thing such as specific selective weed control, soil fumigation, soil sterilization, pre-emergence weed control, etc.

2. Planning a Weed Control Program

   a. Use of herbicides

      1) Field crops
      2) Vegetables
      3) Established legumes and pastures
      4) Aquatic
      5) Rangelands and permanent pastures
      6) Soil sterilization
      7) Perennial herbaceous weeds in cropland
      8) Lawns and ornamentals
      9) Perennial grasses in cropland
      10) Sod renovation

   b. Selection of herbicide (considerations)

      1) Selective herbicides
      2) Non-selective herbicides
      3) Foliage application

         a) Nature of plant surface

b) Spray retention

c) Foliar penetration

4) Root application

5) Functions of constituents of spray solutions

a) Carrier

b) Filming agent

c) Wetting agent

d) Emulsion stabilizer

e) Solvent or coupling agent

f) Toxicant

Note: To illustrate these points, in a fortified oil emulsion spray consisting of water, an aromatic oil, an emulsion stabilizer, and a substituted phenol, water is the carrier; the aromatic oil is the filming agent and acts as the phenol solvent. The emulsion stabilizer acts as a wetting agent, an interfacial-tension reducer to stabilize the emulsion, and in some cases it aids in dissolving the toxicant; the substituted phenol is the toxicant upon which the killing action wholly depends. The other ingredients have very little toxicity in the amounts applied in the spray.

c. Preparation of herbicide for application

1) Solutions

2) Emulsions

3) Suspensions

4) Granules

5) Dusts

d. Method of application

1) Spraying

a) Knapsack sprayers

b) Small hand-propelled equipment

c) Tractor mounted on trailed machines

d) Airblast machines

e) Band sprayers

f) Aircraft sprayers

2) Dusting machines

3) Granular herbicide applicators

4) Fumigant injectors

5) Subsurface applicators

6) Soil incorporation

3. Field Problems Encountered, Cautions, Difficulties - of Using Herbicides

a. Crop rotation - some crop rotations make it possible to use herbicides for weed control, others do not.

Example: Barley ⟶ Cotton

OK ↗

Cotton ⟶ Barley

✗ ↗ Weed control with 2,4-D at this point

b. Spray drift - volatility damage

c. Volatility losses

d. Field safety

1) Toxic materials - livestock, humans

2) Residues

3) Application equipment

4. Recommended Chemical Control Measures in

   a. Field crops (Example of form to use)

Crop	Weed Problem	Chemical	Per Acre Applic. Rate: Active Ingred.	Per Acre Applic. Rate: Gal/Acre	Remarks

   b. Horticultural crops, etc.

Suggested Teaching-Learning Activities

1. Assign students to make recommendations for specific weed control problems given the crop, weed, and other circumstances involved.
2. Visit local farms to determine local problems.
3. Have Extension Agent discuss weed problems and control measures.
4. Prepare complete study guides containing recommended data for the control of all the weeds of importance in various crops in the local area.

Suggested Instructional Materials and References

State Agricultural Experiment Station and Extension publications.

Weed Control guides and recommendations.

VII. To acquire the knowledge and skills needed to handle, transport, store, and apply lawfully and safely those chemicals used as herbicides.

Teacher Preparation

Subject Matter Content

Note: The unit presented under this heading and included in the study guide for the course "The Use of Chemicals as Insecticides" is appropriate to this course if emphasis is placed upon the provisions dealing with herbicides instead of upon insects as was done for that course. (see pp. 41-55)

An additional precaution should be taken with certain herbicides. In some states, California for example, certain herbicides (sodium arsenite, calcium, arsenate, standard lead arsenate, 2,4-D; 2, 4, 5 - T; MCPA, 2,4-DP and Silvex) are classified as injurious materials and before they can be used a permit must be obtained locally from the County Agriculture Commissioner.

Source of Suggested Instructional Materials and References

Crafts, Alden S. and Robbins, Wilfred W., Weed Control, 3rd Edition, McGraw-Hill Book Company, Inc., New York, 1962.

Klingman, Glenn C., Weed Control: As a Science, John Wiley & Sons, Inc., New York, 1961.

Muenscher, W. C., Weeds, MacMillan Company, New York, 1955.

Thompson, W. T., Agricultural Chemicals Book II - Herbicides, The Simmons Publishing Company, Davis, California, 1964.

The British Weed Control Council, Weed Control Handbook, 3rd Edition Blackwell Scientific Publications, Oxford, 1963.

The Herbicide Encyclopedia, Compiled by K. R. Frost, Jr., Extension Agronomist-Weeds, South Dakota, State University, Brookings, South Dakota, 1965.

North Carolina Pesticide Manual, 1964.

Principles of Selective Weed Control, California Circular 505.

Handouts of Glossary, Tables, Charts, Conversions, etc.

State Agricultural Experiment Stations and Extension Service Publications.

Weed Control Guides and Recommendations.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
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THE OHIO STATE UNIVERSITY
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COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
_____

6. How many students:
a) Were enrolled in class (total) _____
b) Participated in studying this module _____
c) Participated in a related occupational work experience program while you taught this module _____

7. Actual time spent teaching module:

		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE - NOT APPROPRIATE
8. The suggested time allotments given with this module were:	
9. The suggestions for introducing this module were:	
10. The suggested competencies to be developed were:	
11. For your particular class situation, the level of subject matter content was:	
12. The Suggested Teaching-Learning Activities were:	
13. The Suggested Instructional Materials and References were:	
14. The Suggested Occupational Experiences were:	

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)